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Assessment of the productive potential of *Dalbergia sissoo* clones through association studies

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Abstract
Experiments were carried out in twenty clones of *Dalbergia sissoo* genetic resources in clonal evaluation trial at Forest College and Research Institute, Mettupalayam to elicit the information on the association studies using biometric attributes during 2012-13. The association study revealed that volume recorded significant and positive correlation with tree height, diameter at breast height (DBH), basal diameter, clear bole height and crown height. The path analysis study indicated that tree height, diameter at breast height (DBH), basal diameter, crown height and clear bole height exercised positive direct effect on volume while number of branches showed negative direct effect on volume. Diameter at breast height (DBH) exerted positive indirect effect via tree height, basal diameter, number of branches and bole height on volume. Hence from the study, the tree height, basal diameter, number of branches and bole height could be used as reliable and relevant indicators for *Dalbergia sissoo* tree improvement programme.

Keywords: Association studies, path analysis, genotypic correlation, phenotypic correlation, sissoo

Introduction

Dalbergia sissoo belongs to the family of Leguminosae (Papilionioideae) and commonly known as Indian Rose wood, Shisham, Sissoo and Thali. Indian forests have undergone a tremendous change in the past few decades and are presently under a great threat. The human dependency on forests is complex and diverse (Tewari, 1994) [22]. The global forest area is over 4.0 billion hectares. The average per capita of the world forest works out to be 0.6 ha (GFRA, 2010) [4]. The mean annual increment (MAI) of Indian Forest is meager of 0.5 - 0.7 m^3 ha^{-1} compared to the global average of 2.1 m^3 ha^{-1} (Srivastava, 2005) [21]. The annual productivity of India's forests is only 3.18 m^3 ha^{-1} yr^{-1}, which is too low compared to other developed countries 8.20 m^3 ha^{-1} yr^{-1} (FSI, 2011) [3]. There is a growing demand for timber and timber products which ushered in a total mismatch between demand and supply. There has been a shift in the emphasis from utilization of often complex natural forests to plantation species which are relatively easy to manage and capable of producing large quantities of wood per unit area (Wilan, 1973) [25]. The demand for industrial wood raw material is also in the ascendancy due to expansion of various wood based industries. The National Forest Policy 1988 emphasized the wood based industries to raise their own raw material requirement without depending on forest and almost all industries in the country are in the process of establishment of captive industrial wood plantations (Lal, 2000) [15].

Despite being a species endowed with an amplitude of utilities and commanding extensive areas, yet it has received little research efforts in genetic improvement. A knowledge on magnitude, nature and type of variation is a pre-requisite for any tree improvement programme (Krishnakumar *et al*., 2017; Zobel and Talbert, 1984) [9, 28]. The best gains can be made for characteristics that have a wide range of variation and are strongly under genetic control (Zobel, 1971; Lacase, 1978; Zobel and van Buijitenen, 1989) [27, 14, 29]. Since Sissoo is extensively being planted for different purposes and plantations are very costly to establish, it is essential that the most productive plant material be used. The ultimate expression of enhanced yield is the culmination of interplay of several component characters. In the integrated structure of a tree, most characters are interrelated with one another and often a change in one is likely to directly or indirectly influence the other. Thus net gain obtained by selecting one may be counter balanced or even negated by a concurrent change in the other.

In the selection programme, understanding of such important association between characters is necessary to make an effective profitable selection.

Materials and Methods

The experimental materials for this study consisted of 20 clones of *Dalbergia sissoo* selected from various locations of Tamil Nadu. The clonal evaluation experiments were carried out in the field of Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam. Clones were planted in a randomized block design (RBD) replicated three times. The clones were planted at the espacement of 3 x 3 m. The biometric observations were recorded at 32 months after planting (MAP) is used to analysis the association studies.

Correlation co-efficient studies

Genotypic and phenotypic correlation coefficients were calculated as per the method suggested by Goulden (1952) [7].

Genotypic correlation

Genotypic correlation was arrived by using the formula as given below

$$r_g.1.2. = \frac{\text{Genotypic covariance between 1 \& 2}}{(\text{Genotypic variance of 1 x Genotypic variance of 2})^{1/2}}$$

Phenotypic correlation

Phenotypic correlation was arrived by using the formula as given below

$$r_p.1.2. = \frac{\text{Phenotypic covariance between 1 \& 2}}{(\text{Phenotypic variance of 1 x Phenotypic variance of 2})^{1/2}}$$

Path coefficient studies

Path co-efficient analysis was carried out as suggested by Dewey and Lu (1959) [1] to study the genotypic correlation coefficients in to direct and indirect effects.

Result and discussion

Correlation studies

Tree height exhibited negative phenotypic (-0.019) correlation and positive and highly significant genotypic (0.848) correlation with volume. Diameter at breast height exhibited positive and highly significant phenotypic (0.831) and genotypic (1.011) correlation with volume. Basal diameter recorded positive and highly significant correlation with volume at phenotypic (0.601) and genotypic (0.770) levels. Number of branches registered negative and non-significant phenotypic (-0.047) and genotypic (-0.146) correlation with volume. Bole height was positive and expressed highly significant phenotypic (0.580) and genotypic (0.741) correlation with volume. Crown height exhibited positive and expressed highly significant phenotypic (0.117) and genotypic (0.178) correlation with volume. Volume showed positive and highly significant phenotypic (1.000) and genotypic (1.000) correlation with volume. (Table 1 and 2). The genetic advance as per cent of mean recorded by this trait was 47.53 per cent which was highest among all the traits.

Table 1: Phenotypic correlation coefficient of biometric attributes of *Dalbergia sissoo* clones

Characters	Tree height	Diameter at breast height	Basal diameter	Number of branches	Clear bole height	Crown height	Volume
Tree height	1.000	0.544**	0.135	0.025	0.238	0.220	-0.019
Diameter at breast height		1.000	0.664**	-0.051	0.605**	0.021	0.831**
Basal diameter			1.000	-0.065	0.771**	-0.174	0.601**
Number of branches				1.000	-0.349	0.289	-0.047
Clear bole height					1.000	-0.168	0.580**
Crown height						1.000	0.117
Volume							1.000

*Significant at 5 per cent level, **Significant at 1 per cent level

Table 2: Genotypic correlation coefficient of biometric attributes of *Dalbergia sissoo* clones

Characters	Tree height (m)	Diameter at breast height (cm)	Basal diameter (cm)	Number of branches	Clear bole height (m)	Crown height (m)	Volume
Tree height	1.000	0.553**	0.421*	-0.186	0.476*	0.344	0.848**
Diameter at breast height		1.000	0.676**	-0.103	0.637**	0.019	1.011**
Basal diameter			1.000	-0.204	0.819	-0.191	0.770
Number of branches				1.000	-0.636	0.576**	-0.146
Clear bole height					1.000	-0.252	0.741**
Crown height						1.000	0.178
Volume							1.000

* Significant at 5 per cent level, ** Significant at 1 per cent level

Path coefficient analysis

The estimates of direct and indirect effects of morphometric traits of *Dalbergia sissoo* on volume under field condition at 32 MAP are presented in Table 3. The residual effect was 0.39.

Direct effect

Among the traits studied, tree height (0.3657), diameter at breast height (DBH) (0.6982), basal diameter (0.1317), crown height (0.0726) and clear bole height (0.0320) exerted positive direct effect on volume but number of branches (-0.0003) showed negative direct effect on volume (Table 3).

Indirect effect

Tree height exhibited maximum positive indirect effect on DBH (0.38619) followed by basal diameter (0.05550) and minimum indirect effect in number of branches (0.00007). The DBH recorded maximum positive indirect effect on tree height (0.2022) while minimum indirect effect was observed in number of branches (0.00004). Basal diameter registered higher positive effect on DBH (0.4718) followed by tree height (0.1540) and the negative effect was observed in crown height (-0.0138) (Table 12). Numbers of branches have maximum positive indirect effect with crown height (0.04183) and the minimum and negative effect were contributed by clear bole height (-0.02035) (Table 12). The trait, clear bole height has positive indirect effect with diameter at breast height (DBH) (0.44487) and negative indirect effect with crown height (-0.0183). The crown height exhibited maximum and positive effect on tree height (0.12580) while negative effect was registered in number of branches (-0.00022) (Table 3).

Table 3: Path coefficient analysis showing direct and indirect effect of biometric traits on volume of *Dalbergia sissoo* clones

Traits	Tree height	Diameter at breast height	Basal diameter	Number of branches	Clear bole height	Crown height
Tree height	0.36572	0.38619	0.05550	0.00007	0.01525	0.02499
Diameter at breast height	0.20229	0.69820	0.08903	0.00004	0.02040	0.00140
Basal diameter	0.15406	0.47183	0.13175	0.00008	0.02623	-0.01387
Number of branches	-0.06811	-0.07223	-0.02683	-0.00038	-0.02035	0.04183
Clear bole height	0.17414	0.44487	0.10792	0.00024	0.03202	-0.01834
Crown height	0.12580	0.01345	-0.02515	-0.00022	-0.00808	0.07264

Residual effect = 0.392, * Diagonals are direct effect

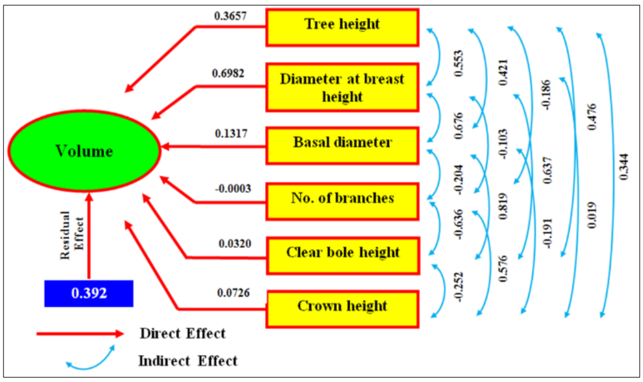

Fig 1: Path diagram showing relationship among volume and its components in clones of *Dalbergia sissoo*

Discussion

In genetic improvement programme of trees, the selection of superior genotype is very important as it forms the very basis for any tree improvement. The success of any tree improvement programme depends on the amount of genetic variability in a tree species and it has got significant importance for developing effective tree improvement strategies (Krishnakumar *et al*., 2018; Vakshasya *et al*., 1992) [10, 24].

Inheritance of most of the economic traits is complex in nature and it is affected by a wide range of associated characters. Presence of significant correlation among those characters which have higher heritability and by environmental variable permits better use of indirect selection (Krishnakumar *et al*., 2018a) [11]. Unfavorable associations among yield (volume) attributes under selection may result in genetic slippage (Dickerson, 1995) [2] and limit genetic advancement. Hence, knowledge on the correlations among such characters is essential while aiming for rational improvements in yield through selection. Correlation study is primarily aimed at knowing the suitability of various traits for indirect selection because selection response for several other traits and the pattern of variation will also be changed. In the present investigation, it was observed that volume showed significant and positive correlation with diameter at breast height (DBH), basal diameter, bole height and crown height. The volume showed positive correlation with tree height in genotypic correlation and negative correlation with phenotypic correlation, the number of branches exhibited negative correlation with volume in both the level. These results were similar to the findings of earlier workers (Giannini and Raddi, 1992; Lambeth *et al.*, 1994; Tewari *et al.*, 1994; Kumar, 2001; Ginwal *et al.*, 2004) [5, 16, 23, 12, 6].

Genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation coefficients after two years of plantation. The genotypic correlations among basal diameter and clear bole height exhibited significant value and diameter at breast height (DBH), volume showed highly significant values which suggested that these characters may be used to the advantage of the breeder for bringing improvement in these traits simultaneously.

Path analysis

Even though correlation analysis measures the relationship between dependent and independent characters, it is not providing exact picture of how much a character constitute on its own and via other characters as the dependent trait. Under such circumstances, path coefficient analysis is of helpful in resolving the correlation into components of direct and indirect effects (Wright, 1921) [26].

Path analysis gives an insight into a complex relationship between different characteristics in a biological system. In the present investigation the tree height, diameter at breast height (DBH), basal diameter, clear bole height, crown height expressed positive direct effect on volume while number of branches expressed negative effect (-0.0003) on volume. The studies by various authors showed that basal diameter had maximum direct effect on its volume in *Santalum album* suggesting a better scope for improvement of volume by selecting this trait (Manoj Kumar Reddy and Suganya Subramanian, 1998) [17] and girth at breast height (GBH) has maximum direct effect on volume followed by plant height indicating the contribution of both these character on volume in Eucalyptus (Patil *et al*., 1997) [18]. Similarly direct effect of tree height, basal diameter, crown height and bole height on volume in the current study also confirmed the results of earlier findings indicating the contribution of these factors on the growth and development (Fig.1). Similarly diameter at breast height (DBH) recorded positive indirect effect via tree height, basal diameter, crown height and bole height on volume which indicated major contribution of these parameters on volume. Hence from the current study high and positive association with intensive direct effect of tree height, basal diameter, crown height and bole height on volume could be used as valuable, reliable and relevant measure for *Dalbergia sissoo* tree improvement programme. Wide range of research findings in different tree species *viz*., *Populus deltoides* (Jha, 2012) [8], *Simarouba glauca* (Kumaran *et al*., 2010) [13], *Terminalia arjuna* (Srivastava *et al*., 1993) [20], *Eucalyptus tereticornis* (Rathinam *et al*., 1982) [19] and

Casuarina equisetifolia (Kumar, 2001) [12] also support the findings of current study.

Summary

The volume exhibited significant and positive correlation with diameter at breast height (DBH), basal diameter, clear bole height and crown height both at phenotypic and genotypic levels. Tree height, diameter at breast height (DBH), basal diameter, clear bole height and crown height exercised positive direct effect on volume while number of branches showed negative direct effect on volume. Hence the parameters which showed positive direct effect on volume could be effectively used as selection criteria to increase tree volume in clones of *Dalbergia sissoo.*

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